INTERNATIONAL EDITION

COMPUTERS AND DATA PROCESSING

Harvey M. Deitel
Barbara Deitel

Computers and Data Processing

COMPUTERS

DATA

AND PROCESSING

INTERNATIONAL EDITION

HARVEY M. DEITEL
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Dedicated with love to
Julius and Miriam Zigman,
our children Paul and Abbey,
And in loving memory of Morris and Lena Deitel

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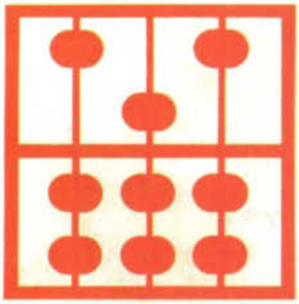

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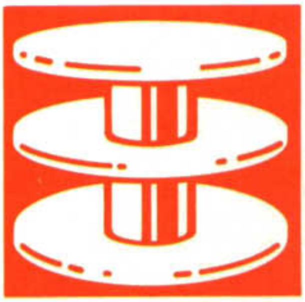

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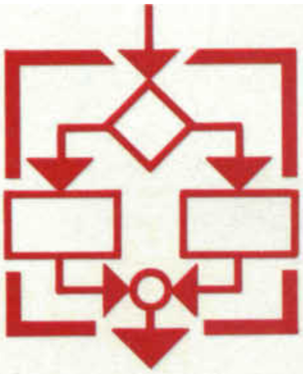

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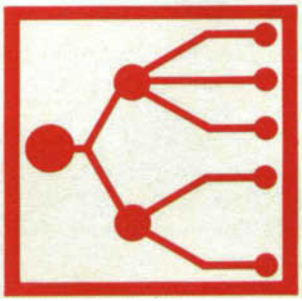

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Preface

Computers and Data Processing is the product of one of the most ambitious research, writing, and production efforts ever undertaken in computer science publishing. Our goals were clear: make the book exciting, complete, up-to-the-minute, innovative, and visually smashing; deal with controversial issues head on, and include humor and anecdotal asides for the reader's enjoyment. The book contains one of the most dramatic and comprehensive graphics packages that has appeared in an introductory computer text.

The average person who will read this text is already well aware of the enormous impact computers are having on our personal lives and business enterprises. A familiarity with computers, how they work, and the kinds of applications they are used for is essential for living in today's increasingly complex world. This text is designed for use in a one-semester college course that introduces the basic principles of computers; it meets or exceeds the guidelines of the major professional organizations for computer literacy courses taught by departments of computer science, management, data processing, information sciences, and others.

We enjoyed writing the text; it gave us an opportunity to immerse ourselves in the most current information available in the computer field. We have read thousands of articles and communicated with hundreds of companies, organizations, and government agencies. We have met hundreds of interesting people at computer trade shows and professional conferences throughout the country, and we have had the opportunity to work with some of the leading professionals in the publishing industry. We sincerely hope you'll enjoy reading the text as well.

Features of the Text

We have loaded *Computers and Data Processing* with innovative materials in addition to presenting traditional basic computing concepts. We probe the reader's mind with challenging questions. We attack controversial issues directly.

The pictures in the text were acquired from hundreds of companies, publishers, and photographers who gave us their enthusiastic cooperation. These photographs and illustrations bring the reader right into the environments where computers are being used; the vast majority of these pictures are supplied as transparencies and color slides for projection in the classroom.

We have included a number of carefully chosen cartoons and anecdotes; our goal is not so much to get fast laughs, but rather to draw the reader's attention to important issues these pieces raise. Consider them carefully; there is much food for thought here.

We have included numerous enrichment pieces that are highlighted against color backdrops. They supplement the text, but we strongly recommend their inclusion in the required readings for the course. The material in these pieces is included in the exercises.

At this point, the reader should turn to the section titled "A Tour of the Text" on pages 8 through 17 for an overview of the book and a discussion of its unique features. This section is especially important to instructors considering the book for adoption.

For those courses that include a programming component, we have provided Chapter 8, "Structured Programming," and Appendix A, "BASIC Programming." Chapter 8 covers the general principles of developing good programs; it is written in a language-independent manner and should be covered in all courses regardless of the particular programming language being used. For courses that use BASIC, Appendix A includes a substantial treatment of the language. The Appendix is carefully divided into four modules. Module 1 presents an introduction to the language. Module 2 introduces the elements of structured programming in BASIC with six case studies covering decision making, looping, counting, totaling, averaging, and finding the largest of a series of numbers; the case studies parallel Case Studies 1 through 6 of Chapter 8. Module 3 presents the more substantial topics of single-subscripted arrays, subroutines, and program development with stubs and drivers; its three case studies parallel Cases 7 through 9 of Chapter 8. Module 4 presents a series of advanced case studies that examine the important topics of fancy print formatting, sorting, double-subscripted arrays, and using randomness to develop simulation programs.

For the Student

We have included several features to help the student master the material. Each chapter begins with an attention-getting illustration, a statement of learning objectives, a chapter outline, and one or more thought-provoking quotations. Each chapter ends with a summary and an alphabetized list of important terms. Twenty self-review exercises—10 matching and 10 fill-in-the-blanks—are included; answers for these are provided to help the student evaluate his or her progress. Ten discussion questions are included to create material for homework and class discussions. Each chapter also includes one or more suggested projects. Many of these encourage the students to perform work outside the classroom—to investigate and experience the applications and implications of computers in the society around them.

A comprehensive **Glossary** includes definitions of the 570 terms that are highlighted in the **Important Terms** sections throughout the text. An especially thorough **Index** includes page references for the approximately 1200 terms that are highlighted in boldface type in the chapters.

The student *Study Guide* is the ideal supplement for the student who wishes to reinforce his or her knowledge of the material and prepare for course examinations. For each chapter of the text the study guide states the learning objectives, includes a section titled "Taking Notes" that provides a detailed outline of the text material, and includes 60 short answer questions with answers—15 true/false, 15 multiple choice, 15 matching, and 15 fill-in-the-blanks. The student who reads the text, reads the notes, does the 20 self-review exercises in the text, and does the 60 self-review exercises in the *Study Guide* should certainly master the material.

Appendix C provides a wealth of information for people considering careers in the computer field or in closely related fields. It discusses many of the popular positions held by computing professionals, describes available educational programs, and lists the key professional organizations and certification programs. Perhaps the most valuable feature of the appendix is its presentation on how to go about searching for a job; the appendix describes how to prepare a résumé and cover letter and provides the names and addresses of more than 100 of the leading employers in the computer industry throughout the United States. College seniors should write to the personnel directors of these and other companies in the fall; many of them will send literature about careers they offer, their salary scales and benefits, and how to apply for jobs they offer.

For the Instructor

We have worked very hard to provide the instructor with valuable teaching materials to help make the classes interesting and enjoyable. We believe strongly in the value of graphics and illustrations, so we have assembled the largest support package of slides and transparencies ever used with an introductory computer science text. We have selected 100 illustrations from the text for the *Transparencies Package*, and we have chosen 270 pictures from the text for inclusion in the *Color*

Slides Package. Thus, most of the art from the text is available for projection in the classroom.

We have prepared a *Test Bank* containing examination questions and answers for each of the nineteen chapters of the text. A *Computerized Testing Service* and *Test Generation Software* are available from the publisher. The *Instructor's Manual* contains numerous teaching hints and provides answers to each of the discussion questions from the main text.

Acknowledgments

One of the pleasures of authorship is acknowledging the many people whose names may not appear on the cover but without whose efforts, cooperation, and encouragement a work of this scope could never have been completed.

We are fortunate to have been able to work with the extraordinary team of publishing professionals at Academic Press. These people had to work under the strain of tight deadlines and demanding authors to make this project happen; they did it with vigor, determination, and dedication.

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We hope you'll enjoy reading our text. We would greatly appreciate your comments and criticisms addressed to:

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We will respond to all correspondence immediately.

Computers and Data Processing

Chapter 1. The Information Revolution
Chapter 2. The Evolution of Computers

Part One

Introduction

Today, thousands of humans desperately lie waiting for tissue-matched organs to become available for life-saving organ transplants; tomorrow economical computerized artificial organs may be manufactured in minutes to a patient's specifications. Our ancestors worked 80- to 100-hour weeks under generally poor working conditions; with tireless computerized robots providing food, clothing, and shelter, it may become possible for future generations to work one- or two-day work weeks or not to have to work at all. With the application of computers to medicine, a person born a few hundred years from now might conceivably expect to live twice as long as someone born today. Thirty years ago computers could play chess about as well as human novices; within the next several decades, a computer is almost certain to capture the world chess championship. Today, if we want a fact we might have to spend hours or days tracking it down; in a few decades the vast majority of facts known to humankind may be accessible to us in seconds from our personal computers. All these developments may come about because of computers—machines that process huge amounts of information at staggering speeds. Part One of this book introduces some fundamental computer concepts, overviews the text, and gives a concise account of the evolution of the modern computer.

Chapter 1

The Information Revolution

After reading this chapter you will understand:

1. What the Information Revolution is and how it is affecting our lives
2. Why it is important to study computers
3. Some of the key benefits of using computers
4. Some of the dangers of increasing our dependency on computers
5. How this text is organized

Left: **The New York Stock Exchange makes extensive use of computers to keep up with today's huge trading volumes that sometimes reach 40 million shares per hour.**

Outline

Introducing the Computer
The Benefits
The Dangers
Looking to the Future
A Tour of the Text

What networks of railroads, highways and canals were in another age, networks of telecommunications, information and computerization . . . are today.

Bruno Kreisky, Austrian Chancellor

We are reaching the stage where the problems we must solve are going to become insoluble without computers. I do not fear computers. I fear the lack of them.

Isaac Asimov

Introducing the Computer

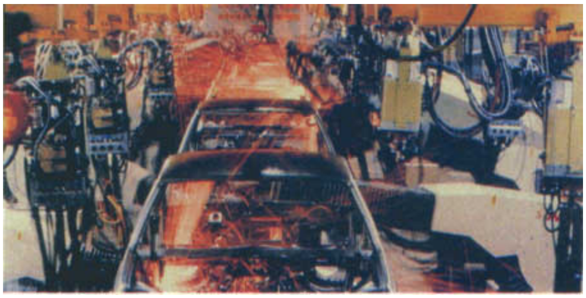
We are in the midst of what is commonly called the **Information Revolution**, a period of change that may prove as significant to our lives as the Industrial Revolution was to our ancestors. Computer technology is at the root of this change, and continuing advancements in that technology seem to ensure that this revolution will touch all our lives. We can only begin to guess the effects of the Information Revolution, but we can be certain that living through the revolution in the 1980s and 1990s will be exciting and challenging.

The machines of the 1800s, which triggered the Industrial Revolution, helped workers extend their muscle power. Most machines assist us in this way. Cars, for example, let us travel farther in less time than we can by foot or horse; typewriters enable us to write with less strain than we can by hand. Computers, however, are unique machines in that they help us extend our brain power. Their capabilities make it possible for us to do in hours what might otherwise take days (such as projecting sales or balancing a budget) and to work other problems we probably could not otherwise handle. We can now manage our personal lives and business enterprises with the useful information computers generate, and we can have that information sooner than if we were to try to create it ourselves. Computers help us tackle difficult personal and business decisions with greater assurance that the consequences of the decisions have been carefully anticipated.

At the beginning of this century the most common occupation in the United States was farming; today it is information handling. Ours has become an information-based society, and we depend on computers to help us handle this information. Computers, unknown to the masses as recently as a decade ago, have now become a common fixture in many homes, classrooms, and small businesses. In the 1940s computers were scarce. In the late 1980s computers will be in most homes and businesses, in automobiles, toys, and appliances.

Businesses are becoming so dependent on computers that in a few years it may be difficult to get a job as an office clerk without having some computer expertise. Computerized robots are already replacing blue-collar workers on assembly lines (Figure 1–1); eventually they may be able to replace white-collar workers as well. Students are being prepared for these changes. But what about people already in industry? Will they be able to adapt as their environments become more heavily computerized? As you will see throughout this book, the impact computers have and will have

Figure 1–1 These computer-controlled robots weld car bodies ten times faster than humans and with much greater accuracy.



"The computer is down! Everybody think!"

©Creative Computing

on society provokes many serious questions. You will be frequently asked to consider carefully the consequences of computer technology.

Within the next decade computers could become the world's largest industry, displacing both the automobile and oil industries. It has been forecast that International Business Machines Corporation (IBM), one of the foremost manufacturers of computers, could become the world's largest company by the year 2000.

Why are computers becoming so popular? Simply put, they are becoming financially accessible and both useful and attractive to more people. As recently as the late 1950s most computers filled entire rooms and cost hundreds of thousands, even millions, of dollars. Today **microprocessors** (Figure 1–2), tiny computers etched onto thin slivers of silicon called **silicon chips**, may be purchased for a few dollars apiece. There is every reason to believe that in a few years the cost of these microprocessors will be so negligible that computing will be almost free. Certainly this will dramatically change our lives.

People are coming into contact with computers daily. These machines, once thought mysterious, are now being used routinely as more and more people are beginning to realize that computers are merely devices that follow sets of instructions, called **computer programs** or **software**, that have been written by **computer programmers**.

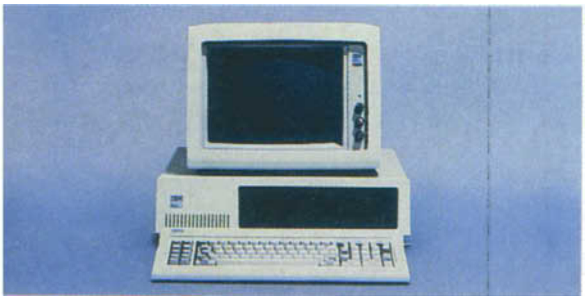
People are finding that the instructions computers follow help to simplify their own lives. Programs may instruct a computer to perform such functions as totaling a store's cash receipts or preparing a company's payroll, customer statements, or tax returns. They may instruct a computer to perform such varied tasks as computing missile trajectories or controlling a robot arm to weld car bodies. They may instruct a traffic control computer when to change traffic lights or an air traffic control computer how to determine whether two planes are on a collision course.

Many people would be surprised to discover that they already own several computers, most likely in the form of microprocessor chips embedded in digital clocks, digital watches, TV sets, home video games, microwave ovens, and automobiles. Home appliances already contain talking computers that warn if the washing machine is overloaded or the dishwasher needs more soap.

The power of the prohibitively expensive "giant brains" of a few years ago is now available

Figure 1–2 The microprocessor chip shown here is as powerful as the room-size computers of a few decades ago.

Figure 1–3 The IBM Personal Computer is one of the best-selling personal computer systems in the world.



Courtesy of International Business Machines Corporation in desktop **personal computers** (Figure 1–3) that cost only from a few hundred to a few thousand dollars. School systems are under tremendous pressure from parents and students alike to increase the use of personal computers and offer more computer courses. Small businesses are already finding it difficult to remain competitive without using computers to assist in such office procedures as preparing payroll, taking inventory, billing customers, and budgeting.

Computers may also be instructed to assist in creating new products. The production and distribution of this textbook was itself highly computerized. The text was written on a word processor (see Chapter 14; see "A Tour of the Text" for more detailed information on this book), and later typeset on a computerized photocomposition system. The photographs and color in the diagrams were processed and prepared with computerized laser-scanning systems (see Chapter 5). In marketing research for this book, computers were used to compile the results of a detailed survey of more than a thousand professors teaching introductory computer courses. Computers scanned lists of faculty members to determine which instructors might be interested in receiving examination copies of the text.

Computers have become so useful in so many areas of life that they have become indispensable to many people. Computers have become a part of our lives.

The Benefits

You may agree that computers are becoming a more important part of our lives but still wonder: Why invest a great deal of time and effort to consider this technology? Part of the answer is that computers are everywhere around us in our personal lives and in our business enterprises. They are one of the most significant technologies that will influence our future.

More importantly, studying how computers work will help you learn how they can help you extend your thought processes. If you want to reap the benefits of most other machines, you need only know how to operate them. You can benefit from a car by driving one, even if you don't understand how it works. Computers operate differently, however. They are problem-solving tools. To benefit from a computer, you must be able to ask the right question about the problem and to manipulate the information correctly to reach an answer. To do that, you must understand the technology.

Once understood and programmed correctly, computers can be used to make life more convenient, more enjoyable, and more rewarding. They can enrich every facet of life. They are fun to use and can help reduce tedious work. They can be used to improve the lives of disadvantaged and handicapped people, facilitate major breakthroughs in medicine, increase leisure time, speed the pace of education, help make businesses more profitable, improve communication, make transportation smoother, safer, and faster, help save energy and conserve other valuable natural resources, help reduce crime, control the cost of government, and extend explorations in outer space. Surely any technology that offers such significant benefits is worth studying!

The Dangers

Although computers can help us improve the quality of our lives, many people consider them potentially dangerous. They fear that computers could be the greatest boon to those who would invade our privacy or wage war against us. Others wonder if computers will relegate us to pushing buttons, thus destroying the incentive to achieve. Some people fear that massive unemployment will result as machines displace workers. They wonder if our computer-controlled weapons of destruction will become so complex that we might lose control of them and cause an accidental nuclear war. Might a poorly designed computer system cause the life support system of an intensive care patient to fail? Will the personal touch disappear? Will society be divided into the "computer-haves" and the "computer-have-nots"? An understanding of computer logic will help to dispel many of these fears.

"They'll never replace Thorndike, there, with a computer . . . because nobody knows what he does."

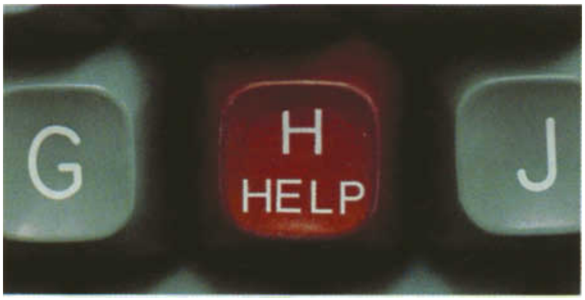


Figure 1–4 The "help" key is one of the most important keys on today's computer keyboards. The user may press it at any time to receive useful information about how to proceed. Providing assistance in this manner makes computers more user-friendly.

Looking to the Future

Despite the fear of computers some people have, most people are somehow involved in the Information Revolution and, therefore, with computers. Although the inflation of the 1970s and early 1980s hit many industries, the costs of computing have been decreasing rather than increasing—in fact, decreasing dramatically. Many people even delay purchasing computers because they hope that the prices will decline even further. Computing costs can be expected to decline to the point that we may soon be able to afford all the computer power we could possibly use, so that almost any imaginable application of computers may be attempted. Similarly, the costs of data communications will also continue declining as transmission capacities increase. Therefore, we will be able to transmit huge amounts of information between computers at great speed and nominal cost.

We can also expect the base of potential computer users and applications to continue to broaden, creating new computing careers and new benefits from computers. This extension of computer use is already evident in the growing interest in purchasing home computers. In fact, as people use computers successfully, they continue to give computers more to do. If computers malfunctioned regularly or if their costs were too high, people would avoid using them. But the experience with computers has been a positive one. It seems as though there is an "applications spiral," with an ever-increasing range of applications being attempted.

Perhaps this growth in the number of users is a result of the important trend toward creating systems that are **user-friendly** (Figure 1–4), that is, systems that can be easily used by untrained people. The really big breakthroughs in this area will not come until the late 1980s and early 1990s. For example, personal computers may already be economical enough for many people to own, but they are still very unfriendly devices. Speech synthesis and speech recognition may help solve this problem as computers converse with their users in everyday English.

Lastly, laser technology will greatly affect the course of computing over the next several decades. A **laser** is a device that creates an intense beam of monochromatic (one-color) light (Figure 1–5). The text contains many in-depth explanations of how the special properties of laser beams are used in today's computers and data communications systems. It has been forecast that by the year 2000 today's electronic computers will be replaced by laser-driven "optical computers."

Will the world be a better place as a result of the Information Revolution, or just a different place? Certainly it will be different. We can help ensure that it becomes a better place by carefully studying computers, examining the many controversial issues raised about them, and devoting careful thought to planning computer applications.